A.D. 1860, *27th January.* N° 206.

Electric Telegraphs, &c.

LETTERS PATENT to Cromwell Fleetwood Varley, of No. 4, Fortess Terrace, Kentish Town, St. Pancras, Middlesex, for the Invention of "Improvements in Electric Telegraphs, Part of the Invention being applicable to other Purposes."

Sealed the 22nd June 1860, and dated the 27th January 1860.

PROVISIONAL SPECIFICATION left by the said Cromwell Fleetwood Varley at the Office of the Commissioners of Patents, with his Petition, on the 27th January 1860.

I, Cromwell Fleetwood Varley, of No. 4, Fortess Terrace, Kentish Town, St. Pancras, Middlesex, do hereby declare the nature of the said Invention for "Improvements in Electric Telegraphs, Part of the Invention being applicable to other Purposes," to be as follows:—

My Invention has chiefly reference to long submarine or subterranean lines, & consists of,—

1. Improvements in the construction & testing of the cable.

2^d^. In the mode of insulating those portions of the circuit that are suspended in the air, & in insulating the line from extraneous currents.

3^d^. In the mode of producing the electric impulses, which are to produce the signals at the distant end.

4. The mode of producing the signals at the far end at a rapid rate.

5. In a mode of producing electricity for the above purposes.

The most important part of the circuit is the conductor; these are usually made of copper wire or strand insulated with a covering of gutta percha or

other suitable non-conductor; if this covering be damaged water is admitted to the conductor; the electricity escapes, & ultimately the conductor is eaten through by electrolytic action, if positive currents be used. I make my conductor of two or more separate wires or strands, each insulated by any suitable material from the other, except as described farther on. These two or more conductors are used as one conductor.

For ease of explanation, assume that my cable's conductor have three conducting wires, each surrounded with gutta percha; these three are connected together at frequent intervals, as follows:—First, Nos. 1 & 2 are connected together by soldering or otherwise; a little further on Nos. 2 & 3 are connected, & further on still Nos. 1 & 3 are so joined, & so on, the different metallic junctions breaking joint, and no two of them being in the same spot. Excepting at these junctions, the separate conducting wire are isolated from each other. Now if the insulating covering be damaged water enters, & the wire becomes defective, I then apply strong positive currents to the cable, which eat away the conductor till its exposed ends retire inside the insulating envelope, & ultimately these offer so much resistance that the line will be workable again shoud the insulating covering be damaged so much as to expose two of the three wires, these two will be eaten away, & the third one will carry the current. Thus a cable may be injured in several different places, & yet be made available after sending currents through it for a month or so, & this without materially increasing the resistance of the line. Where the lines are extended overground on poles to the station I do not insulate them with porcelain or glass insulators, but metal ones cover'd partially or wholley with vulcanised caoutchouc, by Daft's patent process, dated the 28 January 1860, No. 227. For this purpose I prefer iron, & in some cases I coat the surface of the caoutchouc with Venice turpentine, rosin, or other suitable non-conductor; or I make a ring-shaped cup in the interior of the insulator, & fill it with Venice turpentine or other similar compounds. In this way I can stamp up pieces of metal, place a metal pin inside it, & insulate the two from each other by Daft's process, & yet they are united so strongly by the caoutchouc that no ordinary ill treatment will break them. In rocky places or where the soil is an imperfect conductor, the discharge of elect electricity from the atmosphere to the earth, or from the lower to the upper strata of the earth, interfere with & reduce the speed of working the line. I insulate my lines from this influence by making connection with the earth several miles out to sea; for instance, in the thick shore end of the cable there shoud be two conductors or more, one or more of them to be connected either to a large metal plate or to the

exterior iron wires of the cable by careful soldering in several places. I prefer using zinc plates for this purpose made very thick, & attached to the iron of the cable. In this way I get an earth connection several miles out to sea, & free from by far the greater part of the disturbing influence. These partial return circuits also neutralize to a considerable degree the effects of magnetic storms, & render the cable much less liable to damage by lightning. The most rapid signals are produced by instantaneous discharges of measured amount of electricity.

For a really instantaneous discharge into the cable the tension must be indefinitely great to produce a signal of sufficient force, such tensions endanger the cable, hence the objection to induction coils. I therefore use induction plates similar to those patented by me on the 5th December 1854, No. 2555, & use them in the following improved manner:—I charge them by the machine described further on, & discharge them into the cable to produce the required signals, or I charge them by means of batteries connected to them through resistance coils or other suitable means of resistance, or I connect them as follows:—To one end of the battery I join the plates answering to the inside of a Leyden jar, & the other plates answering to the exterior of the jar are used as the other pole of the battery for giving the signals; in this way at the first moment of contact between the battery line & earth the signal is produced, & the plates charged on reversing the connections. I have the force of the charge in the the plates added to that of the battery; by this means I get at the first moment of contact a powerful discharge rapidly decreasing in in tension, & of measured amount measured by the capacity of the induction plates.

Induction plates being bulky & expensive, I use in most instances plates or wires of platina, (gold, carbon, or other conducting substance, not decomposable by the electrolytic action in the solution used, may be substituted for the platina). Two of these plates are placed in each cell containing sulphuric acid & water, a number of these cells are connected together like a voltaic battery, consisting of plates of the same metal, instead of dissimilar metals. When so many of these are used that the battery cannot decompose the water they become induction plates of great inductive capacity, & a few inches of surface give as great inductive capacity as many miles of submarine cable; these are used as before described. I sometimes attach such plates to local circuits, & so elongate the short marks or dots, & thus make an almost momentary contact, give an intelligible signal, & which, under ordinary circumstances, would not have been recorded, thereby increasing the speed of working. These induction plates may be used to store up electricity for blasting or other purposes. I use

at the receiving end of long submarine, or other lines, relays, which record the impulses, whether the electric wave pass the zero or not, that is to say, the relay is made to indicate the rise or fall of the wave, whether it pass the zero or not, & thus I get much greater rapidity. I effect this by one of the following means:—I use a galvanometer relay, as patented by me on the 16 February 1854, No. 371, but instead of using a fixed stop for the contact piece to strike against I mount a fork, between whose limbs the contact piece vibrates on an axle having a due amount of friction; this yields to the action of the contact piece, & thus any variation of the current, from say, positive to less positive, or vice versa, produces a signal by the motion between the forks, whether the needle passes zero or not, the prongs being insulated from each other; or, I use the following plan of relay, in which the local circuit is never broken. The needle is mounted horizontally & carries a platinum wire dipping into a vessel (say glass) containing a suitable solution, say, sulphuric acid & water, this vessel is divided into two or more compartments, all connected together, & over which the platinum wire passes, each of these compartments have connections so that the current passes chiefly into that one over which the platinum wire is situated for the time being. I prefer connecting these compartments with relays similar to those already invented by myself, but wound with two wires. In this way, by using a chemical or mechanical recording machine, with two or more writing points, the rise & fall of the electric wave is recorded, & this without the wave passing the zero. Professor Thomson has effected a similar purpose by means of his reflecting galvanometer, & a man to record what the reflector shows.

My Invention records itself by local circuit. This relay has a peculiarity, viz., it never breaks contact, but simply shifts it from one compartment to the other, without leaving the fluid.

For testing the cable to ascertain that the conductor is nowhere too near the surface of the insulator, I patented the use of charges of high statical electricity, on the 9th June 1855, No. 1318; I obtain these charges by a new method, which can also be used for obtaining electricity generally for any other purpose. I place an insulated plate or conductor near or between two other suitable conductors, the latter being charged statically induces in the former the contrary electricity, the inner plate being connected to the earth to give or take the positive electricity. This plate is then removed & placed between two other plates, & first allowed to touch them, by which it gives them its acquired charge, the plate is then removed from contact with the exterior plates, & connected to earth, by which it acquires a charge of the opposite kind to the

former one; it is then taken back to the first pair, placed inside, & there gives up its new charge; it is then removed from contact with them, put to earth, & charged as before; thus, by continuing the process, the charge rapidly augments to the required amount. By this contrivance, a little modified mechanically, the most sensitive test for statical electricity is obtain'd. I prefer mounting these on non-conducting plates & rotating them, the rotation making & breaking the necessary contacts. Where great tension is required, I insulate the plates of my machine with non-conducting materials, prefering vulcanised caoutchouc, or place the whole apparatus in a vessel containing a non-conducting fluid, such as spirits of turpentine, or, what is better, place it under an air-tight vessel, & compress air into it, by which means I get any amount of insulation. These plates may advantageously be used in connection with induction coils for increasing the tension of the electricity; in this case I make the induction coil charge one or more of the plates by making the spark leap across a given interval, & this interval I prefer dividing into 2 or 3, & when necessary keep a current of air blowing against them. This prevents the charge from discharging itself back through the conducting tube or line of heated air made by the previous spark, in this way I can use the induction coil for charging Leyden arrangements instead of the ordinary electrical machine. These coils may be advantageously inclosed in compressed air for insulation.

Lastly, to preserve the cables from lightning, I use vacuum lightning conductors invented by me in 1847, & connect the conductors to the vacuum, & make the earth connection by soldering to the iron wires of the shore end of the cable; with such an arrangement it is impossible for the cable to be hurt by lightning.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said Cromwell Fleetwood Varley in the Great Seal Patent Office on the 23rd July 1860.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, Cromwell Fleetwood Varley, of 4, Fortess Terrace, Kentish Town, St. Pancras, Middlesex, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Twenty-seventh day of January, in the year of our Lord One thousand eight hundred and sixty, in the twenty-third year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the

said Cromwell Fleetwood Varley, Her special licence, that I, the said Cromwell Fleetwood Varley, my executors, administrators, and assigns, or such others as I, the said Cromwell Fleetwood Varley, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPHS, PART OF THE INVENTION BEING APPLICABLE TO OTHER PURPOSES," upon the condition (amongst others) that I, the said Cromwell Fleetwood Varley, my executors or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said Cromwell Fleetwood Varley, do hereby declare the nature of my said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement, that is to say:—

My Invention has chiefly reference to long submarine or subterranean lines, and consists of,—

1st, improvements in the construction and testing of the cable.

2nd, in the mode of insulating those portions of the circuit that are suspended in the air, and in insulating the line from extraneous currents.

3rd, in the mode of producing the electric impulses which are to produce the signal at the distant end.

4th, the mode of producing the signals at the far end at a rapid rate.

5th, in a mode of producing electricity for the above purposes.

The most important part of the circuit is the conductor. These are usually made of copper wire or strand insulated with a covering of gutta percha, or other suitable nonconductor. If this covering be damaged, water enters to the conductor, the electricity escapes, and ultimately the conductor is eaten through by electrolytic action if positive currents are used, the cable is then useless for telegraphic purposes. I make my improved conductor of two or more separate wires or strands, each insulated by any suitable material from the other, except as described further on, these two more conductors are used as one conductor.

For ease of explanation, assume that the cable's conductor have three con-

ducting wires, each surrounded with gutta percha or other insulating material; these three are connected together at frequent intervals, as follows:—First, Nos. 1 & 2 are joined by soldering or otherwise, a little further on 2 & 3 are joined, and further on still 1 & 3 are so joined, then again 1 & 2, 2 & 3, 3 & 1, and so on alternately throughout the cable; each and every one of these joins being carefully covered over with the insulating material, the different metallic junctions breaking joint, so that no two of them shall occur in the same spot. Excepting at these junctions the separate conducting wires are isolated from each other. Now, if the insulating covering be damaged, water enters, and the wire becomes defective; I then apply positive currents to the cable, or what is better, positive currents intermitted now and then by negative currents of short duration, to eat away that portion of the conductor till its exposed ends retire so far within the insulating envelope as to offer resistance enough to make the line workable again. Should the insulating covering be so much damaged as to expose two of the three wires, these two will be eaten away, and the third will carry the current over until it arrives at the other junctions of the wires, where the current will again divide into the different wires of the compound conductor. Thus a cable may be injured in several different places, and yet be made available after sending positive currents thro' it for a month or so, and this without materially increasing the resistance of the line. When positive currents are applied for a long while, and the injury in the cable happens to be in clay or mud, the exposed wire at the fault becomes quickly covered by an insulating film, the short negative currents break down this insulation, and thus expedite the eating away of the exposed conductor. When the ends of the conductor are eaten away so far inside the insulating covering that negative currents do not make much impression, the cable can be used again. Such a cable should be worked with a preponderance of positive currents, and then the more it is used the less will be the irregularity and inconvenience arising from the defect.

I prefer constructing these conductors as follows:—1st, cover three wires separately with one coat of insulating material, and then join them together, as already explained at stated intervals, viz., 1 & 2, then 2 & 3, and still farther 3 & 1, and again 1 & 2, and so on; this done, the compound conductor is covered with one, two, or more coats of insulating material inclosing the three or more wires of the compound conductor. Where the lines are extended overground on poles to the station, I use metal insulators, covered partially or wholly with vulcanised caoutchouc, (by Daft's Patent process, dated 1860, No. 227,) which causes it to adhere perfectly to the metal.

Figs. 1, 2, 3, & 4, are sections of such insulators, the smaller the pin *a* the better for insulation; so I prefer steel pins *a* (coated with brass or not), these are covered to about $\frac{1}{12}$ of an inch in thickness with Daft's india-rubber; disks of this material may be formed round the pins, as in Fig. 2, to increase the insulation. *b*, *b*, the metal caps, these are sometimes coated on the inside with the india-rubber, and by coating their outsides they are rendered more durable, and tend to increase the insulation. Fig. 3 shews a cup around the pin, to contain resin and turpentine, or other suitable insulating substance, whose surface resist the deposition of moisture. Fig. 4 shows a cap with its mouth partly closed. These insulators are not easily injured by stones or rough usage. I sometimes coat the vulcanized caoutchouc with a mixture of rosin, shell lac, and Venice turpentine, to which has been added a quantity of powdered silica, or simply with Venice turpentine, which gives it a smooth and highly non-conducting surface.

In rocky places, or where the soil is an imperfect conductor, the discharge of electricity from the atmosphere to the earth, or from the lower to the upper strata of the earth cause rapid currents to flow in and out of the cable; these false signals greatly interfere with and reduce the speed of working the line. I insulate my lines from this influence by not using an earth connection at the station, but one placed several miles out to sea; for instance, within the thick shore end of the cable there should be included two or more distinct conductors insulated from each other, one or more of them to be connected either to a large metal plate, or to the exterior iron wire, by soldering at or near to the sea termination of this larger cable where it is joined on to the smaller or deep sea portions of cable; in this way I get an earth connection several miles out to sea, and at a distance from the source of atmospheric disturbance. The discharges from the atmosphere produces false and very rapid signals, and are quite distinct from the magnetic storms or auroro borealis currents. The nature of the coast must determine how far out to sea the earth connections should be made. These short return circuits also neutralize to a considerable degree the effect of magnetic storms (which appear to be much more powerful across the land than across the ocean), and render the cable less liable to damage by lightning. The most rapid signals through long cables are produced by instantaneous discharges into the conductor of measured amounts of electricity.

For a really instantaneous discharge into the cable the tension must be indefinitely great to give a signal of sufficient force, such tensions endanger the cable, hence the objection to induction coils, I therefore use induction plates similar to those patented by me on December 5, 1854, No. 2555, and

apply them in an improved manner. I charge them by a machine described farther on and discharge them into the cable to produce the required signals, or I charge them by means of batteries connected to them through resistance coils as shown in Fig. 5, or other suitable means of resistance.

The induction plates *a* and *b*, are charged by the batteries *c* and *d*, through the resistance coils *e* and *f*; the alternate plates of the induction series *a* and *b*, are connected to the earth; these charge like a Leyden battery, and when the intermediate plates are connected to the line, freely discharge themselves into it, producing a rapid signal followed by the battery current, which is limited by having to pass thro' the resistance coils *e* or *f*; the positive & negative wires *g* and *h*, connects them to a key as shown at *i*; the key when up sends a negative discharge followed by a feeble current; when half way it connects the line to earth, and when down disconnects the earth and sends a positive discharge into the line, followed by a feeble current; or I connect the induction series with a key, similar to that patented by me in 1854, No. 371. between the key and the line, or with one like Fig. 6; on turning the switch the plates are charged; on depressing the key the connections are reversed. The force of the charge accumulated in the plates, added to that of the battery, producing a powerful discharge rapidly decreasing in tension and of measured amount, measured by the capacity of the induction plates; the same action in the opposite direction taking place when the key is elevated.

Induction plates being bulky and expensive, I use, in most instances, plates or wire of platinum (gold, carbon, or other conducting substance not decomposable by the electrolytic action in the solution used, may be substituted for the platinum). Two of these plates are placed in each cell containing sulphuric acid and water, or other suitable fluid; a number of these cells are connected together like a voltaic battery consisting of plates of the same metal instead of dissimilar metals. When so many of these are used that the battery cannot decompose the water, no gas is formed on their surfaces, and they are induction plates of great capacity, a few inches of surface giving as great inductive capacity as many miles of submarine cable.

Professor Jacobi, of Russia, has for many years used on the line between St. Petersburgh and Moscow, plates of platinum in sulphuric acid at the ends of the line to produce a somewhat analogous action. I do not claim the use of induction plates in a fluid, but my improvement consists in using such induction plates in conjunction with my system of working printing telegraphs, which differs from the Morse, Baines, and other systems in this respect, that the signals are produced by the reversal and not by the intermission of the current.

Jacobi used induction plates to produce a current in the opposite direction to that originally sent by the Morse key, the battery limited and opposed by the induction plates producing the signal, and the induction plates alone the reversal or discharge, this reduced the strength of the signal very considerably. I use the induction plates in conjunction with the battery, and thus get a discharge whose tension at the first moment is equal to that of the plates added to that of the battery, i.e., nearly double the force of the battery alone, and thus the short signals or dots are strengthened instead of weakened by the introducing of the induction plates. I further take care to use so many plates that no gas is evolved on their surface; if gas be evolved on their surface they form a gas, the currents from them then depend on the amount of gas evolved rendering their action very irregular and uncertain. Leaden plates can be used when a smaller number of them will be found available, this arises from the formation of peroxide of lead (as is well known) on the positive surfaces, their action is not so regular as where the pure inductive action free from electrolytic action is used, as is the case where the induction plates are platinum and too numerous to allow of the decomposition of the water. Induction being incomplete, electrolysis, I sometimes attach induction plates to local circuits to elongate the marks, and thus make an almost momentary contact of the relay, give an intelligible signal which otherwise would not have been recorded, and thus increase the speed and certainty of working.

Figs. 7 and 8, represent modes of applying induction plates to local circuits. *a*, magnet coil of recording machine; *b*, induction plates; *c*, local battery; *d*, relay contact. A momentary contact at *d*, charges the induction plates *b*, which are made of such size that they alone, when charged, will produce a signal on the recording machine.

When using the induction plates for blasting or similar purposes, I prefer connecting them in the following manner:—A rotating or other compound switch or commutator connects all the plates marked +, Fig. 9, together, and also to the positive pole of a battery of one or two elements; all the plates marked —, being connected to the negative pole. When the plates are charged the switch or commutator is reversed, when all the plates are connected, as in Fig. 10, and discharged into the wire leading to the fuse. In this way the action of a single cell (within certain limits) can be made to store up a large quantity of electricity, by connecting the battery to the plates as in Fig. 9, for several minutes, and by connecting the plates as in Fig. 10, the stored up electricity can be discharged, with any tension desired, according to the number of plates used. With a series of twenty pairs of plates, and one

cell of Groves' battery, 2 inches by 4 a fuse may be discharged at 200 yards every 10 minutes or quicker.

I use at the receiving end of long submarine or other lines, relays which record the impulses, whether the electric wave pass the zero or not, and thus get much greater rapidity. I effect this by one of the following means:—I use a galvanometer relay as patented by me in 1854, No. 371, February 16th, but instead of using a fixed stop for the contact piece to strike against, I mount a fork, between whose limbs the contact piece vibrates on an axle having a due amount of friction, this yields to the action of the contact piece, and thus any variation of the current from, say, positive to less positive, or vice versa, produces a signal by the motion between the forks, whether the needle pass zero or not, the prongs being insulated from each other. Fig. 11, S, N, magnet of galvanometer relay (vide Patent 371, 1854). *a*, its axis; *b*, bent arm for making and breaking the local circuit; *c*, the moveable fork mounted on an axle *d*; *e*, a fan in the oil cup *f*; *g*, an adjoining cup with plunger *h*, and adjusting screw *i*, to force as much oil into *f*, as will give the needed amount of obstruction to insure contact, one leg of the fork *c*, Fig. 12, is insulated by covering it with glass tube *j*, or other suitable means; *k*, a magnet on the axle *d*, this and the magnet S, N, above, are adjusted to suit the current by auxiliary magnets not shown, or springs may be used for this purpose, or instead of the galvanometer relay I use the relay patented by me Decr. 24th, 1856, No. 3059, Fig. 23 & 24 of that Patent, the centre piece *f*, being magnetized with the same pole as the electro-magnets is repelled by them and vibrates between a fork similar to that in Fig. 11. These relays record the rise or fall of the electric wave, and thus work quicker through long submarine lines than the ordinary relays, they close the circuit while the wave is increasing from negative to positive, or from negative to less negative, or from positive to more positive, or vice versa.

The following relay records the rise or fall of the electric wave, and does this without any mechanical break of contact of the relay connection; it is suitable for very feeble currents coming through very long lines. Fig. 13, N, S, the needle magnet in connection with one pole of the local battery; it is mounted on a pivot or pivots over the centre of the semicircular trough *a*, *a*, Fig. 14, which has several partial or imperfect divisions *b*, *b*, like the separate one, Fig. 15, of non-conducting material. The narrow gaps *c* are to allow of the free passage of the platinum or gold arm *d*, which dips into the trough of fluid *a*, *a*, whichever way it is deflected, either to the right or to the left. Separate platinum plates *e*, *e*, &c., are placed at bottom of each division of the

trough; each of these plates are connected with a needle at *f* of a compound chemical recording telegraph, there being as many writing needles *f* as there are divisions in the trough. When the needle N, S, is deflected, it carries the pin *d* thro' one or more of the narrow openings *c*; it then acts with the particular plate *e* over which it is situated. The pin *d* is flattened and spread out a little wider than the thickness of the partitions. Where necessary a platinum plate is inserted in the partitions as at *g*, and connected with the other pole of the local battery, it then intercepts the currents escaping from the division in which the pin *d* is situated to the two on either side of it.

The plates *e* in the divisions, instead of being connected to a chemical recording telegraph, as shown, may be connected with relays similar to those used with Morse's instruments, and the latter connected to a Morse machine, carrying 7 or more points. In this way indented records are obtained on dry paper, and the most feeble currents are capable of effecting this. This arrangement not only records the general rise and fall of the wave, positive and negative, but also removes all difficulty arising from imperfect contact at the relay when very feeble currents are employed. These relays are sometimes used with only two compartments, and connected to a relay similar to those previously patented by me, but wound with two wires in opposite directions, the one being connected with one cup, the other with the other cup. These are chiefly of use for working Morse machines with very feeble line currents where the electric wave is rapid; a magnet or spring, not shown, is used to regulate the very light magnet N, S. Professor Thomson has effected a similar purpose by means of his reflecting galvanometer and a clerk to watch and record what that shows. My Invention records itself by local circuit. For testing the cable to ascertain that the conductor is nowhere too near the surface of the insulator, I patented the use of charges of high statical electricity. I obtain these charges by a new method, which can also be used for obtaining electricity generally for any other purpose. I place an insulated plate or conductor near or between two other suitable conductors; these being charged statically induces in the former the contrary state, the inner plate being momentarily connected to earth to give or to take positive electricity. This plate is then moved and placed between two other plates and then allowed to touch them, by which it gives them its acquired charge, then moved out of contact, but while between them it is made to touch earth, by which it acquires through induction a charge of the opposite kind to the former one; it is then taken back to the first pair, to

which it gives up its new charge, then moved out of contact, but while between them it touches earth, which renews the first charge but a little stronger; thus by continuing the process the charge rapidly augments to the required amount.

Figs. 16, 17, & 18 shows this principle developed into a machine for producing statical electricity without friction or chemical action, mechanical force causing induction to act alternately positive and negative, or + & −. *a, a,* axle carrying the rotating plate *b* made of vulcanite or glass; on this are mounted the plates of wood, *c, c,* &c. These, and the plate *b*, are supported by and rotate between two sheets of window glass or other non-conductor *d, d,* and on which are fixed two pairs of plates or cheeks *e, e,* e^1, e^1; *f*, f^1, conductor balls projecting from them. Each pair of cheeks *e, e,* and e^1, e^1, are separately connected by their bars *g* and g^1, which pass through the glass plates *d, d,* and have central balls to meet the various knobs of *c, c,* &c., as they pass. *h* and h^1 are earth connections covered with glass tubes or other suitable material; these have knobs to meet the passing knobs of *c, c,* &c.; *i, i,* and *j, j,* insulated wires to connect two plates *c, c,* as they pass.

Action.

Having given to the cheek *e* a charge of positive electricity, it by induction action drives out of *c* its positive electricity, rendering it negative at the moment it passes the knob *h*, and all the plates *c* are thus acted on as they pass in rotation; these negative plates then arrive at g^1 and make the cheeks e^1 negative, then while between these cheeks they pass the earth knob h^1, from which they now take a positive charge and pass on to the lower *g*, through which they charge in succession the first cheeks *e*, rendering them more and more positive, the induction power of which renders them still more negative every time they pass the earth ball *h*, and thus by continuing the rotation the cheeks *e* receives charges from *c, c,* and sends them forward more negative, while the opposite cheeks e^1 are being rendered more negative, and causes the plates *c* to take more from the earth and carry it forward on to the first cheeks *e*. Thus by rotating the machine the charges in *e* and e^1, augment until the insulation is insufficient and the electricity escapes.

The wide glass plates *d, d,* both support and insulate the various parts, and prevent the electricity escaping from *e*, e^1, to *c, c,* &c. I prefer making the plates *e*, e^1 of highly polished wood. The connections *i*, i^1, and *j*, j^1, are to increase the power of the machine.

In this machine, to avoid friction, the pieces *c, c,* &c., do not quite touch the

balls g, g^1, and h, h^1, as they pass them, but when I use this machine as an electrometer, I remove the connections i and j, and put spring connections to h, h^1, and g, g^1; then on giving a charge to f, no matter how feeble, and rotating the machine, the charge will be augmented till it is of sufficient force to be measured.

I attach small Leyden jars to the plates e or their balls f until the ratio of augmentation corresponds to the logarithmic number, and thus, if 30 turns, double the charge;

60	multiply it	4	times;
90	„	8	„
120	„	16	„
180	„	64	„

To use this machine, I prefer the following modus operandi:—Fig. 19 represents two portions of a light sphere, the upper, a, attached and suspended by a light spiral spring b, which is insulated by the glass stem c, the lower one d is uninsulated. The strength of spring and distance between these is such, that they are attracted together by a power equal to 1,000 cells of Daniel's battery; the upper one is connected to my electrometer.

This instrument having been charged by any feeble source of electricity is separated from it and then rotated until the charge in the upper curved surface a overcomes the spring. Having counted the number of revolutions necessary to produce this attraction, enter the logarithmic table with it; suppose 100 turns have been necessary to produce the attraction, its corresponding number being 10, it will show that the charge has been augmented 10 times, and that the original charge was $\frac{1000}{10} = 100$ cells of Daniel's battery.

I place these machines under glass covers in which chloride of calcium or sulphuric acid keeps the whole dry.

These electrometers have no limit to their sensitiveness, and will show the tension of a thermo-electric pair. They are covered with a wire gauze under the glass cover, which with the framework of the machine must be connected to earth. This gauze is necessary to cut off extraneous induction, otherwise the simple walking on the ground will charge the operator and his machine sufficiently to derange very delicate tests.

Where a definite multiplication is required a series of plates are used and connected, as in Fig. 20; such a machine, when all six plates are used, multiplies about 2,000 times, and one cell of Daniel's battery will give on this machine sparks six inches in length. The same letters indicate similar parts, as in Figs. 16, 17, 18, but the cheeks e are mounted on glass pillars d instead

of glass plates. *k, k,* are earth plates; *l, l,* rods, with springs *m, m, m*; on turning these up to touch the connecting straps *n, n,* all the cheeks *e* will be discharged. Fig. 21 shows the general arrangement and connections of the parts.

Where great tension is required I insulate the plates of my machine with non-conducting materials, prefering vulcanized caoutchouc, or place the whole apparatus in a vessel containing a non-conducting fluid, such as spirits of turpentine; or, better, place it in an air-tight vessel and compress air into it, by which means any amount of insulation may be had. These plates may advantageously be used in connection with induction coils for increasing the tension of electricity; in this case I make the induction coil charge one or more of the plates by making the sparks leap across a given interval, and I prefer dividing this interval into two or three smaller ones, and when necessary, keep a current of air blowing against them; this prevents the charge from flying back through the line of air heated by the spark. In this way I can use the induction coils for charging Leyden arrangements instead of the ordinary electrical machine. These coils may be advantageously inclosed in compressed air for insulation.

Lastly, to preserve the cable from lightning I use vacuum lightning conductors, invented by me in 1847, and connect the conductors to the vacuum, and make the earth connection by soldering to the iron wires of the shore end of the cable; with such an arrangement it is impossible for the cable to be hurt by lightning.

Claims.

I do not confine myself to the forms mentioned, as they may be modified in many ways. I do not claim the use of two or more conductors in a cable; but I claim the use of two or more conductors joined together at frequent intervals; these conductors being otherwise electrically insulated from each other.

I claim the means described of making a damaged cable workable by destroying a portion or portions of its compound conductor.

I claim the insulators or supports for suspended telegraph wires, as shown in Figs. 1, 2, 3, 4, in so far as regards the use of vulcanized caoutchouc united to the metallic portion of the insulator during vulcanisation, I do not confine myself to the forms shown.

I claim the use of the partial return circuit for getting earth connections some distance out to sea.

I claim the method of obtaining statical electricity, described and shown by Figs. 16, 17, 18, 20, 21, in which the electric force is obtained from mechanical power direct by means of electro-static induction.

Also, the use of these instruments as electrometers and electroscopes of any amount of sensibility.

The use of compressed air for obtaining greater insulation in electrical apparatus.

The method described of charging Leyden arrangements by induction coils, whereby the latter can be substituted for electrical machines.

In witness whereof, I, the said Cromwell Fleetwood Varley, have hereunto set my hand and seal, this Twenty-third day of July, in the year of our Lord One thousand eight hundred and sixty.

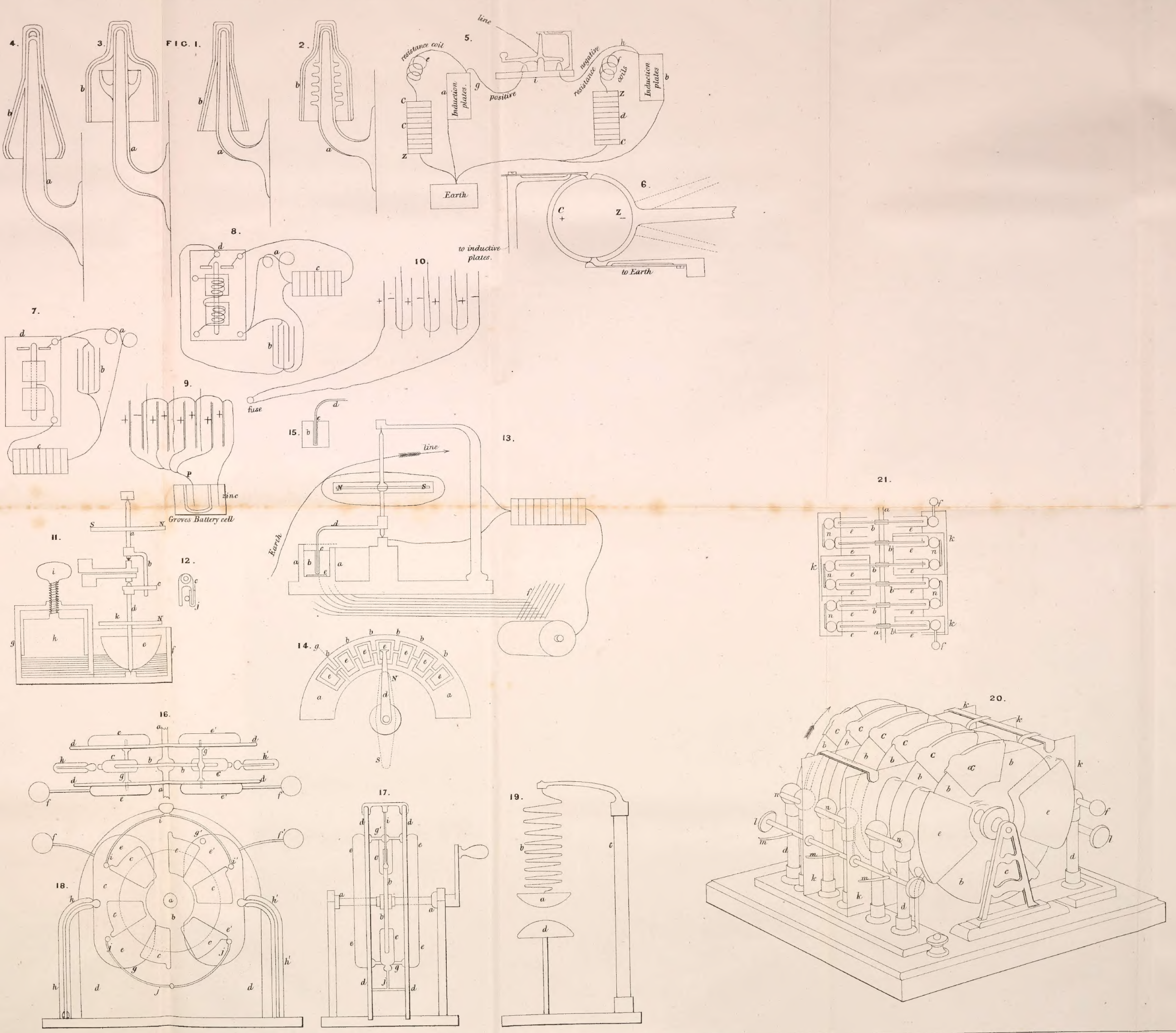
CROMWELL F. VARLEY. (L.S.)

Witness,

Cornelius Varley, Agent.

LONDON:
Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1860.

A.D. 1860. JAN. 27. Nº 206.
VARLEY'S SPECIFICATION.



The filed drawing is not colored.

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